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The Potential for Heat Recovery from Beef Rendering Operations

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Preface

This report is published as part of a continuing research program designed to reduce the costs of marketing agricultural products from producer to consumer.

Research data for this report was developed for the U.S. Department of Agriculture by Quad Corporation, Highland Park, Ill. The Quad Corporation also designed the heat recovery system discussed in this report.

The author expresses appreciation to the staff of Quad Corporation for their important contributions, and to the meat packing firm that cooperated by making its facilities available for this study.

October 1983

The Potential for Heat Recovery from Beef Rendering Operations

By Charles L. Goulston[1]

Introduction

Estimates derived from information provided by the National Renderers Association, *Render* magazine[2] and the U.S. Department of Agriculture's *Agricultural Statistics,*[3] indicate that 25 billion pounds of animal byproducts are rendered annually. This includes the production of slaughterers and meat processors as well as independent renderers. It also can be estimated that this much rendering consumes 19.5×10^{12} BTU's[4] of heat per year (see appendix 1). Shown differently, this represents 19.5 trillion BTU's of heat per year. At a present cost of about $5 per million BTU's, the cost of heat for rendering would be $97,500,000 per year.

With energy costs continuing to rise, and supplies of energy sources becoming more scarce, it is important that efforts be made to find ways to reduce the energy requirements of the rendering process, or to recover a portion of the heat input for use elsewhere.

This publication reports on a heat recovery subsystem installed in 1976 as part of a total rendering system at a major midwestern meat packing firm. Included is a description of the total system and an economic evaluation of the heat recovery subsystem, including costs and potential savings.

While this report describes a specific rendering system, indications are that similar results can be achieved in similar rendering systems.

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[2]Render magazine, February, 1978, pages 8 to 11, 19, Vol. VII, No. I.

[3]U.S. Department of Agriculture, Agricultural Statistics, pages 352, 406, U.S. Government Printing Office, 1980.

[4]BTU is an abbreviation for British Thermal Unit. It is defined as the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

General Description of Rendering Operations

Rendering is the breaking down of cells of various animal tissues to produce tallow and protein byproducts through application of heat.

Many different rendering processes are in use but they can be categoried as either batch- or continuous-type, and either dry or wet.

Dry rendering is much more common than wet rendering. In dry rendering the steam used for rendering the product does not come in direct contact with the product. The raw material is dumped into a closed vessel surrounded by a metal jacket; heat is applied by admitting steam into the jacket. In wet rendering, the steam comes in direct contact with the product being rendered.

In the batch-type rendering system (fig. 1), raw material is dumped into a bin; conveyed to the hogger, where it is ground into smaller pieces; then conveyed to one or more batch cookers where heat is applied. This evaporates moisture from the product and causes the fat to melt. Cooking times vary, depending on the amount and type of product being rendered. The evaporated moisture is discharged into a condenser and then into an odor control system. The melted fat (tallow) is al-

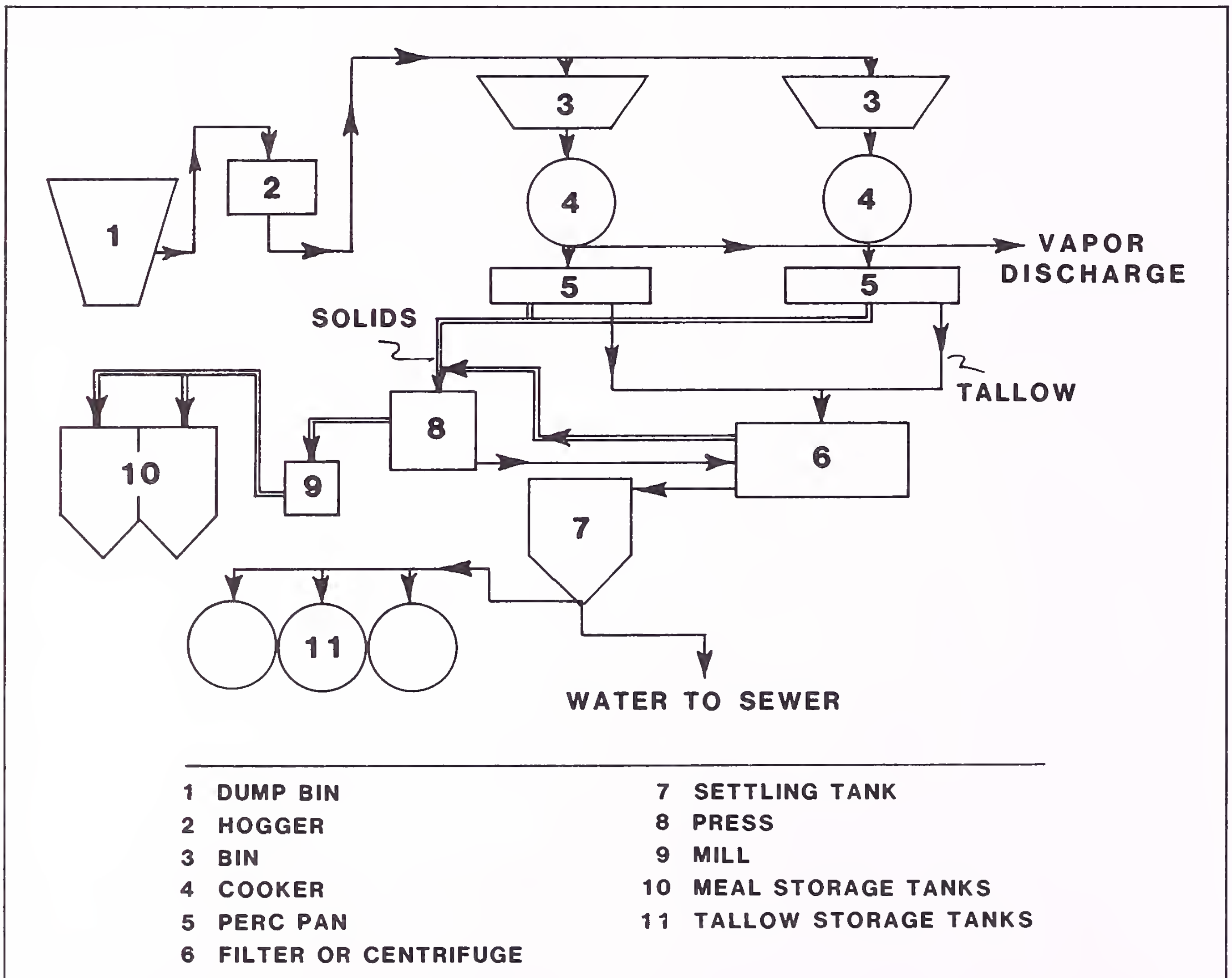

Fig 1.—Flow diagram of batch-type rendering system.

lowed to drain into pans and then is clarified in a centrifuge or filter. The remaining solids are conveyed to a press to remove additional fat. The tallow is further purified in a settling tank, while the solids are further processed into meal.

In principle, the continuous-type system (fig. 2) is the same as the batch-type, except that multicompartment cookers are used. Raw material continuously enters the cooker(s), progresses through the various compartments, and is discharged continuously from the final compartment. This system is typified by a more uniform discharge of vapor since product in the various stages of the cooker is continuously losing moisture. By comparison, the vapor discharge from the batch system fluctuates considerably with time and materials. Industry members indicate that the continuous system is becoming more popular and its use is steadily increasing.

Several variations of these systems exist. Some use less energy than others. Some use heated air rather than steam to heat the product. Equipment manufacturers and users are constantly searching for improved methods and lower costs.

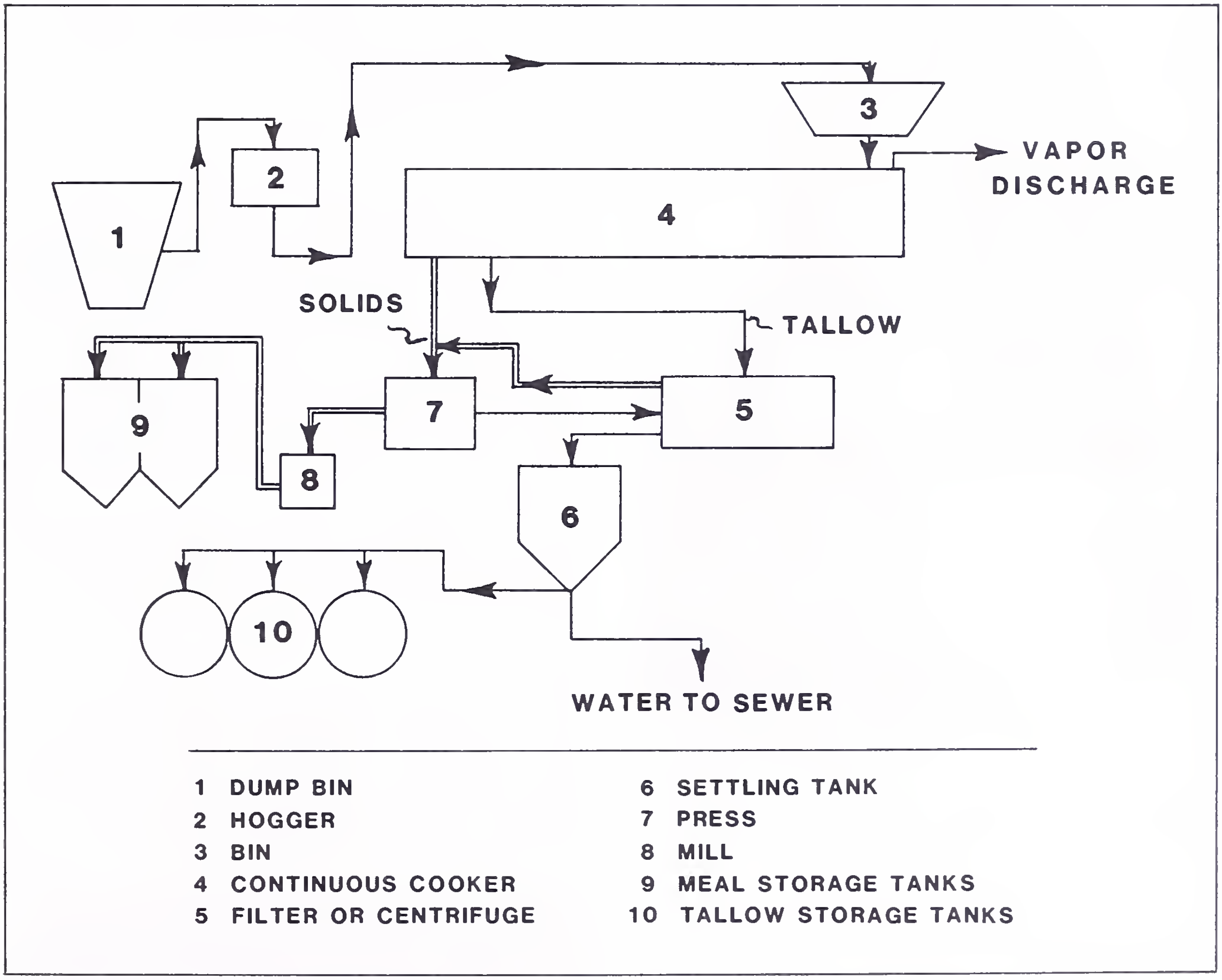

Fig 2.—Flow diagram of continuous-type rendering system.

The Researched Rendering System

The rendering system which was studied for this report is a continuous-type dry system which incorporates the most widely used equipment. It was well suited to heat recovery applications and subsequent evaluation for several reasons. The user was a large meat packer who slaughtered 300 steers and 150 sheep per hour. Consequently, a consistent supply of product flowed through the system at a fairly uniform rate. Had this system been operated by an independent renderer, it would have been more difficult to evaluate since independent renderers are called upon to render a wide variety of raw materials at varying volumes.

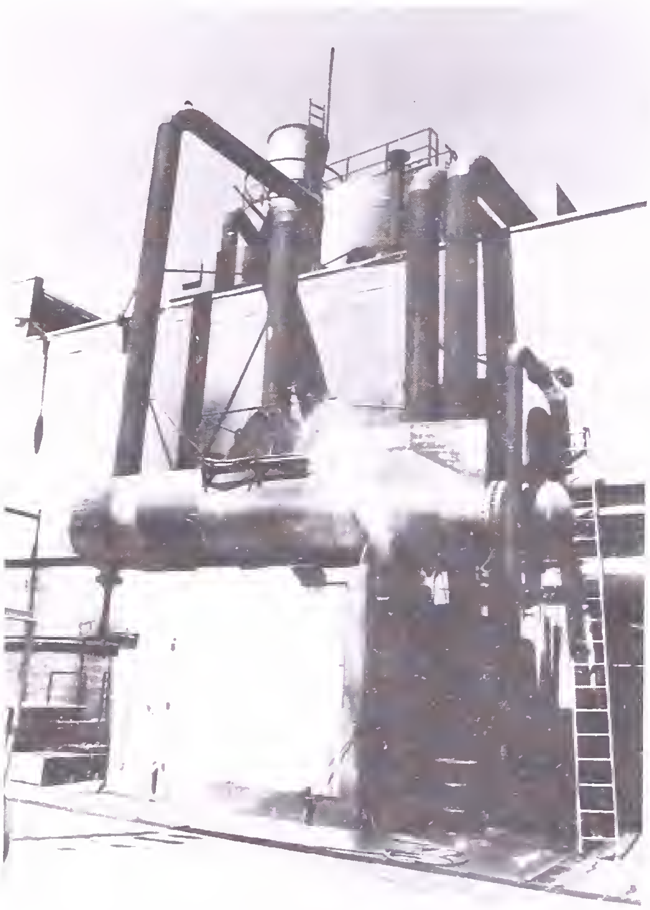

Figure 3.—Main condenser and related ducting.

Description

The complete rendering system consists of three subsystems, rendering, heat recovery, and odor control, which are connected by a series of ducts and pipes. The rendering subsystem consists of three continuous-type cookers and their peripheral equipment. The heat recovery subsystem consists mainly of two condensers (or heat exchangers) and a series of related ducts, pipes, and valves. The main condenser (fig. 3) is used to recover heat from the vapors which escape from the product being rendered. The second condenser, a much smaller one, recovers heat from the condensate of the steam used in the rendering process. Noncondensable vapors from the main condenser are fed into the odor control subsystem. The odor control subsystem is not discussed further in this report since it is irrelevant to the evaluation of the heat recovery subsystem.

Determining Heat Recovered

To determine the amount of heat that was recovered from the rendering process, readings and measurements had to be taken at various points in the system. Data had to be collected and recorded and calculations made based on that data and some established engineering data. The data collected and used in the calculations include the following: the flow rate of steam into the cookers, steam temperature and pressure, number of cookers operating, volume of condensate flowing from cookers, pressure of condensate, flow rate and entering and exiting temperatures of the clean water through each condenser.

Figure 4 is a simplified diagram of the rendering system on which the study calculations were made. It shows how the heat recovery equipment ties into the rendering equipment, and the sources from which heat is recovered.

Data was collected on several days, both during testing of the system and actual production. The calculations, however, were based on data collected on one day, when the operation of the equipment and the data collection were closely controlled. Checks were made to assure that the data used in the calculations were completely consistent with that of other days.

Specifically, the amount of heat given up by the vapors and steam in each condenser was determined. Also determined was the volume of clean water heated in each condenser and the degree to which the water was heated. By comparing the two, one can be reasonably sure that the results are accurate.

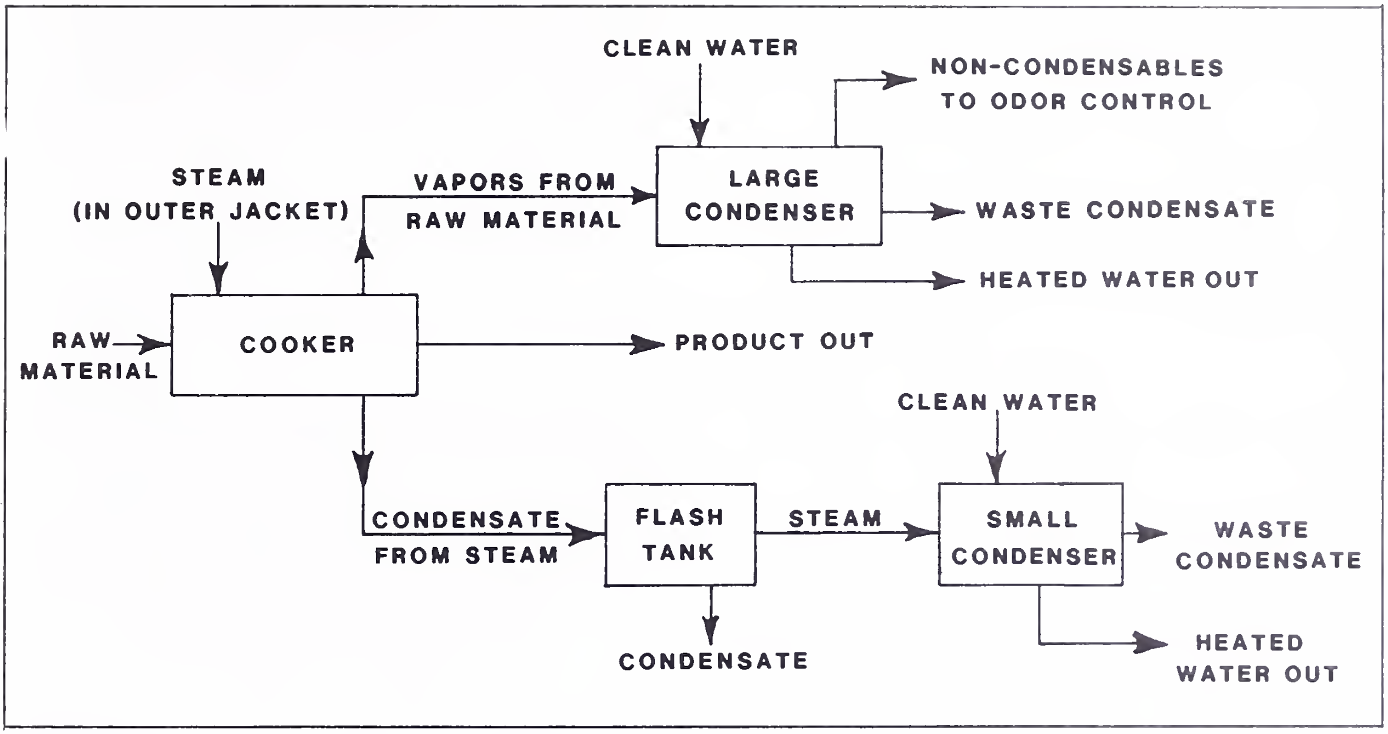

Fig. 4.—Process flow diagram of the researched rendering system.

The amount of heat given up by the vapors and steam in each condenser was 17.007×10^6 BTU's per hr with one cooker in operation. Based on the volume of clean water heated and the amount of temperature rise, 16.943×10^6 BTU's per hr were recovered by the condensers. These two figures compare very closely, confirming their accuracy. Based on the flow rate and pressure of steam entering the cooker during this same period, the heat input was 22.635×10^6 BTU's per hr. The percentage of heat recovered is calculated from the above figures as follows:

$$\frac{16.943 \times 10^6 \text{ BTU/hr}}{22.635 \times 10^6 \text{ BTU/hr}} = 74.85\%$$

Economic Evaluation

To make a realistic and accurate economic evaluation of this particular heat recovery system, it is first necessary to assign a value to the heat which was recovered. Using data from Johnnie and Aggarwal[5], and adjusting to compensate for 1981 energy costs, the value of heat recovered from the rendering system, in the form of steam, is estimated to be $5 per million BTU's. This figure represents the sum of all operating costs and fixed costs; it is based on an assumption of 80 percent boiler efficiency. Readers are urged to reevaluate the cost of steam when making their own projections concerning potential savings from a heat recovery system.

The following costs reflect 1981 estimates:

A. Cost of two condensers, based on $40 per square foot of stainless steel heat transfer surface is

[5]C.C. Johnnie and D.K. Aggarwal, "Calculating Plant Utility Costs," Chemical Engineering Progress, vol. 73, No. 11, Nov. 1977.

$210,000. Cost of engineering, freight, and installation is 30 percent of initial cost of equipment or $63,000. Total equipment cost is $273,000.

B. Maintenance costs of two condensers are $9,000 per year.

The expected life of this equipment is conservatively estimated at 10 years. Although it is recognized that this equipment will have some salvage value at the end of 10 years, zero salvage value is assumed for simplicity.

The equipment is operated for 10 hours per day, 5 days per week, 52 weeks per year for a total of 2,600 hours per year.

In the previous section, it was stated that 16.943×10^6 BTU's of heat were recovered each hour by the heat recovery system. Since that was based on only one cooker, and all three cookers were identical and connected to the same condensers, then one can assume that $16.943 \times 10^6 \times 3$ or 50.829×10^6 BTU's per hour can be recovered from the three cookers in the rendering system.

Since this equipment is operated for 2,600 hours per year, and the cost of heat, in the form of steam, is $5 per million BTU's as stated above, then the savings derived from the heat recovery system is calculated to be 50.829×10^6 BTU's per hour × 2,600 hours × $5 per million BTU's = $660,777 per year.

Using the above developed data, it is now possible to make an economic evaluation of this particular heat recovery system. When comparing two systems or alternatives (in this case the presence of a heat recovery system versus no heat recovery system), the payback period of the investment can be easily determined by dividing the initial investment by the average net cash flow. The net cash flow represents the annual benefits minus the annual operating costs. Since the initial investment cost was determined above to be $273,000, annual benefits or savings were $660,777, and annual operating costs were $9,000 for maintenance, then the payback period (P) is calculated as follows:

$$P = \frac{\text{initial investment}}{\text{annual benefits - annual costs}} = \frac{\$273{,}000}{\$660{,}777 - 9{,}000} = 0.42 \text{ years}$$

From this simple calculation, it is already apparent that the heat recovery system is an extraordinary investment.

The payback method used above has several shortcomings, however; it ignores the life of the equipment, it ignores the cost of borrowing money or the interest that could have been earned had the money been invested elsewhere, and it disregards costs of insurance and property taxes. Taking these factors into consideration, a more realistic evaluation follows:

Estimated Owning and Operating Costs for Heat Recovery System

Amortization, capital cost[1]	$60,746
Maintenance[2]	9,000
Insurance and taxes[3]	8,190
Total owning and operating costs	$77,936

[1]Based on 10-year life and 18-percent interest rate using standard payment table.

[2]Developed earlier in this section.

[3]Yearly average based on 3 percent of initial investment.

Since the annual owning and operating costs are $77,936, and the annual energy savings are $660,777, then the net savings due to installation of the heat recovery system would be $660,777 less $77,936, which equals $582,841 annually.

Income tax considerations did not enter into the above calculations due to the variations of tax positions from firm to firm and the continuing changes of corporate tax laws. Taxes should be considered in any major investment decision.

Conclusion

The heat recovery system that was studied was capable of recapturing about 75 percent of the heat input to the rendering system. In terms of BTU's, a total of 132.155 billion BTU's of heat were recovered annually. Based on a cost of $5 per million BTU's of heat, this system saved $660,777 per year in energy costs. After considering amortization of capital cost, maintenance, insurance and taxes, installation of the system resulted in a net savings of $582,841 per year before taxes.

It is important to note that these savings can be achieved only if the firm has a use for the heat which was recovered. In this particular case, all the recovered heat was used to produce hot water for use in the firm's process operations. It also would be possible to use this heat to preheat water for the boilers which produce the steam, or to warm office or plant space.

In summary, heat recovery systems are capable of saving rendering firms large sums of money. If a firm is able to use the recovered heat, then installation of such a system deserves prime consideration.

Appendix 1

Industry equipment suppliers claim that between 1.3 and 1.7 pounds of steam are required in the rendering process for every pound of water evaporated from the product. After further investigation, it appears that 1.7 is more realistic.

From information contained in Render magazine[6], we can calculate that 13.1 billion pounds of water were evaporated by rendering approximately 25 billion pounds of product in 1976. The following calculation determines the pounds of steam required to render this much product:

$$13.1 \times 10^9 \text{ lbs water} \times 1.7 \frac{\text{lbs steam}}{\text{lb water}} = 22.3 \times 10^9 \text{ lbs steam}$$

Generally, it is accepted that 1,000 BTU's of heat are required to produce a pound of steam. Given that assumption, the following calculation can be made to determine the amount of heat required to produce 22.3 $\times 10^9$ lbs steam:

$$22.3 \times 10^9 \text{ lbs steam} \times 1{,}000 \frac{\text{BTU's}}{\text{lb steam}} = 22.3 \times 10^{12} \text{ BTU's}$$

This is a preliminary estimate of the total heat used in rendering in 1976.

Since about 25 percent of rendering is done with more energy-efficient equipment, the above figure of 22.3 $\times 10^{12}$ is reduced to 19.5 $\times 10^{12}$ BTU's of heat.

[6]See footnote 2.

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